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"Finally, the growth and maintenance of new synaptic terminals makes memory persist. Thus, if you remember anything of this book, it will be because your brain in slightly different after you have finished reading it. This ability to grow new synaptic connections as a result of experience appears to have been conserved throughout evolution."

Kandel E. In Search of Memory, The Emergence of a New Science of Mind. (2006). W.W. Norton & Company, New York, pp. 276.

Aphasia Nation, Inc. is committed to educating the wider public about stroke and aphasia and the "*Aim High for Aphasia!"* international Aphasia Awareness campaign.

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Aphasia Insights!

Karl Spencer Lashley: In Search of the Engram.

By Tom Broussard, Ph.D.

This is the next in a series of articles about the science and scientists behind the brain, stroke, aphasia, plasticity and recovery.

Karl Spencer Lashley (1890 -1958)*

Karl Spencer Lashley (June 7, 1890– August 7, 1958) was born in Davis, West Virginia and died suddenly in Paris, France. He was an American psychologist and was ranked as the 61st most cited psychologist of the 20th century. He was elected to the American Philosophical Society, the oldest learned society in the U.S., dating to 1743. Since 1957, the Society has awarded the annual Karl Spencer Lashley Award in recognition of work on the integrative neuroscience of behavior (Wikipedia).

He obtained his bachelors at West Virginia University, his master's at the University of Pittsburgh, and then Johns Hopkins University, where he received his PhD in genetics in June 1914, under John B. Watson, and focused on specific problems in learning and the brain (Wikipedia).

The word, engram, was coined by Richard Semon (1859-1918), a German zoologist and an evolutionary biologist as described in Semon, R. (1921), *The Mneme*, London: George Allen & Unwin.

Lashley spent 30 years looking for the engram that Semon had proposed by "trying to trace conditioned reflex paths through the brain or to find the locus of specific memory traces" (Lashley, 1950, pp. 3).

An engram is an element of thought, memory and cognitive information that is engraved into certain neurons (or patterns of active neurons) where, theoretically, memories can be stored. Semon stated that "This I call the *engraphic* action of a stimulus, because a permanent record has been written or engraved on the irritable substance. I use the word *engram* to denote this permanent change wrought by a stimulus" (Semon, 1921, pp. 24). As part of his experiments, Lashley trained rats in a variety of tasks

while looking for their new learning characteristics.

As a result of the training, he knew that there had to have been some pathway or memory trace to encode (or convert) the stimulus into the new learning and behavior.

In order to establish that the physical pathway actually existed, he removed different portions of the brain and measured the learning behavior after the removal of the brain tissue.

After many of these operations, and after taking cuts at various points in the brain, Lashley began to see that "no reduction in accuracy of performance when almost the entire motor cortex, along with the frontal poles of the brain, was removed" (Lashley 1950, pp. 4).

Lashley had trained the rats but couldn't find the pathway from the point of entry into the brain that carried the messages to the neuro-engraving sites.

At that point, the engram theory was breaking down, given that the "connections or memory traces…are either diffused through all parts of the cortex, pass by relay through lower centres, or do not exist" (Lashley 1950, pp. 9).

In another attempt to determine where the pathway might be, he removed more and more tissue of the visual cortex to see at what point the animal could no longer see well. The rat could discriminate between the visual figures and was still able to learn "when only one-sixtieth of the visual cortex remained" (Lashley 1950, pp. 16).

At that point, Lashley realized that the memory traces were located in every part of the functional area. His experimental results were counter to the original engram theory. The memories are not localized in one very specific place in the brain but are distributed within the functional areas of the cortex.

Lashley coined two new words and principles based on his work. Equipotentiality defines the idea that if one part of the brain is damaged, other parts of the brain can "take on" other memory functions for the damaged part. Mass action is where the reduction in learning is proportional to the amount of brain loss from the damage.

Lashley referred to Thorndike's aggregate theory of intelligence, as "the quantity of intelligence in any individual is the result of the number of connections, existing or possible, within the nervous system" (Lashley, 1929, pp. 2). In this case, the connections (the *c*'s) in the brain are the synapses that connect one neuron to another.

He wrote that if individuals "differing in the number of *c*'s which they possess but alike in other respects, are subjected to identical environments, the amount or degree of intellect which anyone of them manifests … will be closely proportional to the number of *c*'s which he possesses" (Thorndike, 2012/1927, pp. 415-416).

People with aphasia have lost millions of connections but the remaining healthy cells can grow new connections based on persistent and repetitive language activities. It is all about the *c*'s!

Signed: *The Johnny Appleseed of Aphasia Awareness*

*Harvard photo credit, Lashley, http://www.isites.harvard.edu/icb/icb.do

The author is a three-time stroke survivor and aphasia. He could not read, write or speak well and it took him years to recover.

He is Founder and President, Aphasia Nation, Inc., a non-profit organization whose mission is educating the wider public, national and international, about aphasia and plasticity, the foundation of all learning.

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